

An aerial photograph of a vast sea ice field. A prominent, dark, winding lead (open water) cuts through the ice from the top left towards the bottom right. The ice consists of numerous small, textured floes and larger, smoother areas, showing varying shades of white and light blue under the sky's reflection.

# **Navy Sea Ice Forecasting - Recent Updates and Future Plans**

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Jacobs Technology**

**Credit: 2013 NRL flight off Barrow, Alaska**



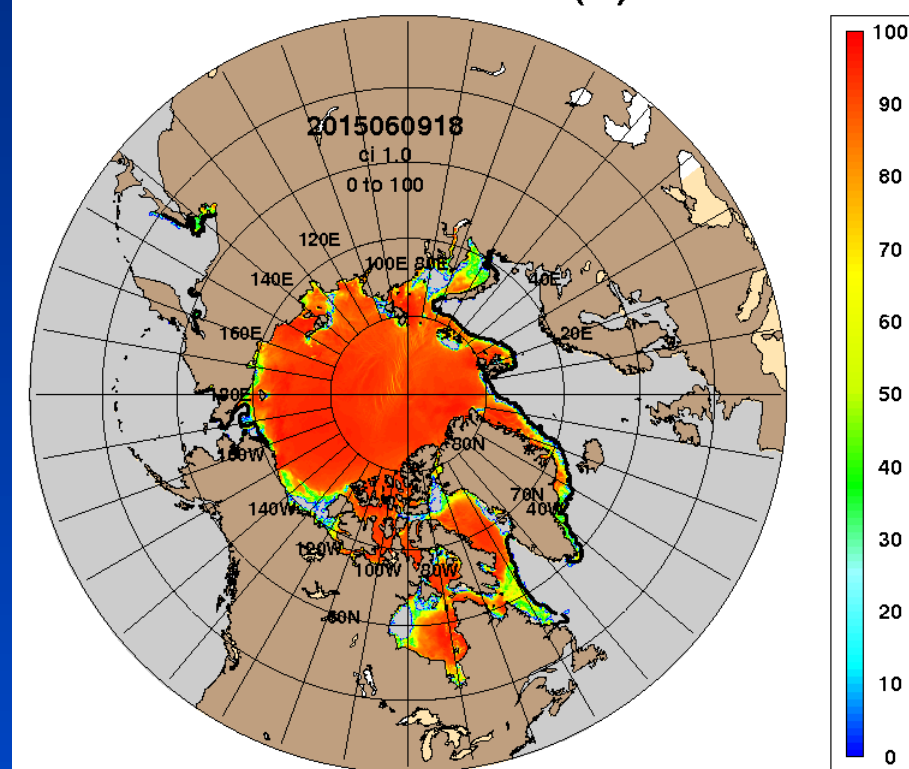


# Arctic Cap Nowcast/Forecast System (ACNFS)

[www7320.nrlssc.navy.mil/hycomARC](http://www7320.nrlssc.navy.mil/hycomARC)

- ACNFS consists of 3 components:
  - Ice Model:** Community Ice Code (CICE)
  - Ocean Model:** HYbrid Coordinate Ocean Model (HYCOM)
  - Data assimilation:** Navy Coupled Ocean Data Assimilation (NCODA)
- Declared operational Sept 2013
- Runs daily at the Naval Oceanographic Office (NAVO)
- ACNFS produces nowcast/7-day forecasts of ice concentration, ice thickness, ice drift, sst, sss and ocean currents for the Northern Hemisphere
- Products pushed daily to the U.S. National Ice Center (NIC) and NOAA

ARCc0.08-04.0 Ice Concentration (%): 20150607



Grid Resolution ~3.5 km North Pole

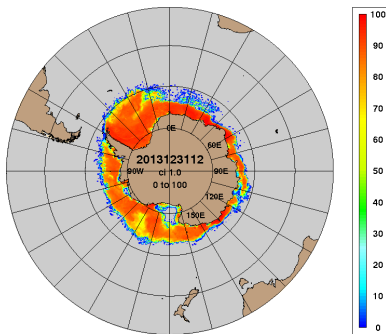
Black line is the independent ice edge location (NIC). Animation spans June – July 2015



# Global Ocean Forecast System (GOFS 3.1)

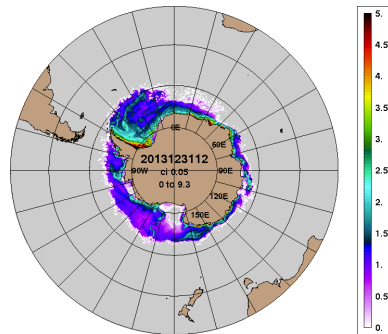
- 1/12° global two-way coupled HYCOM-CICE modeling system with data assimilation
  - Uses HYCOM/CICE/NCODA like ACNFS but with improved HYCOM and NCODA
  - Currently undergoing operational testing by NAVO/NIC
  - After GOFS 3.1 becomes operational, it will replace ACNFS
  - Added capability of forecasting ice conditions in the southern hemisphere

GLBb0.08-29.2 Ice Concentration: 20140101



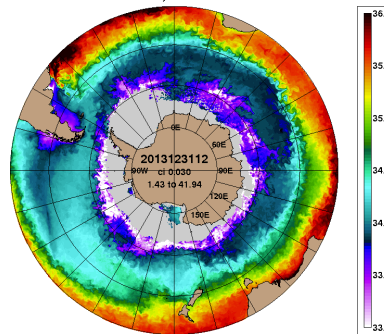
Ice  
Concentration (%)

GLBb0.08-29.2 Ice Thickness: 20140101



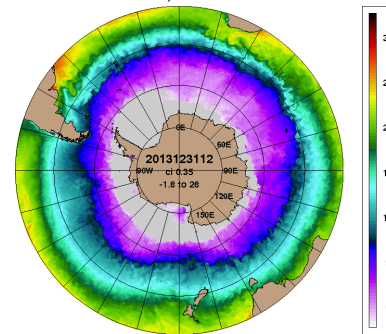
Ice  
Thickness (m)

SSS Jan 01, 2014 00Z 29.2



Sea Surface  
Salinity (psu)

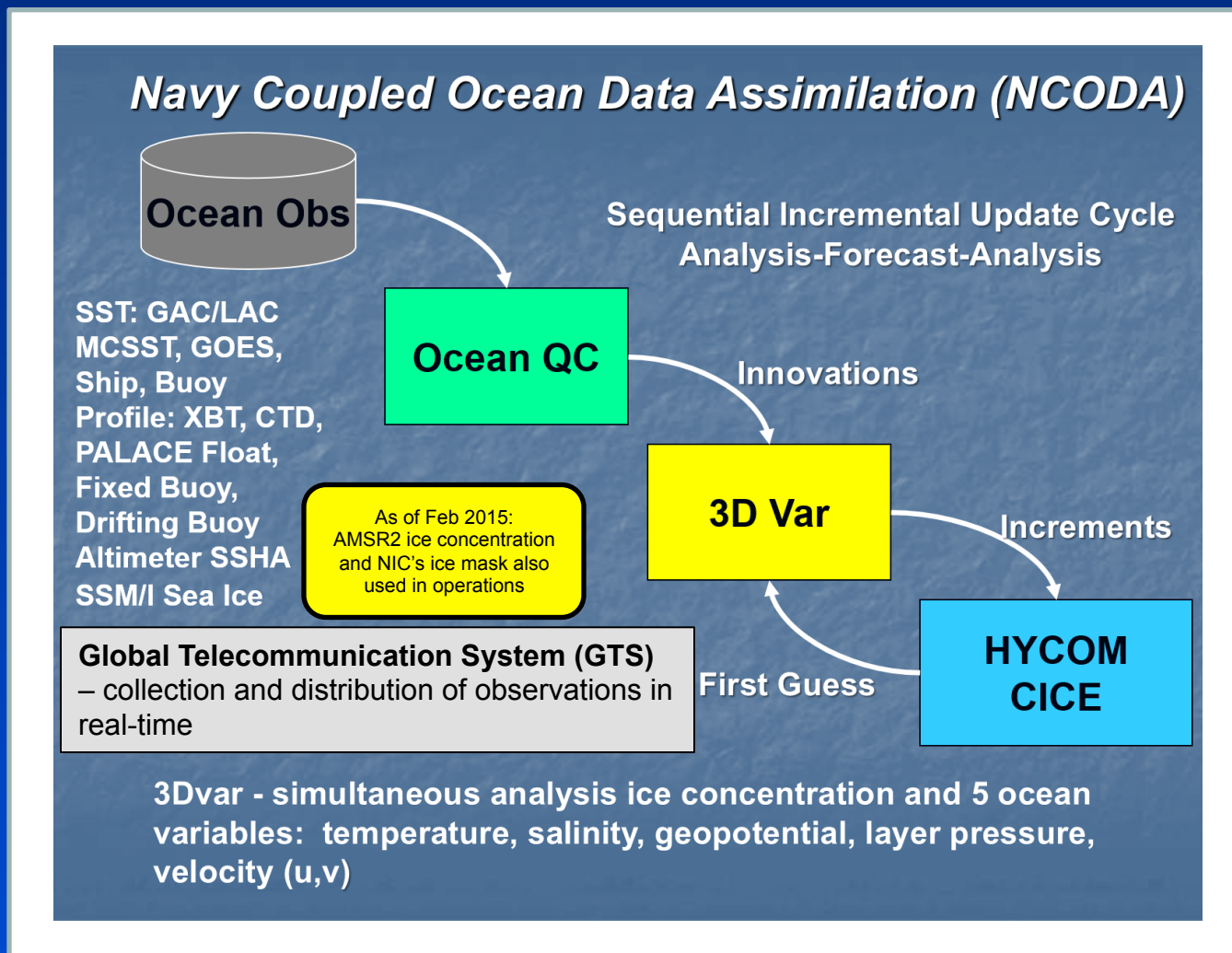
SST Jan 01, 2014 00Z 29.2



Sea Surface  
Temperature (C)



# Observations used in the Navy's assimilation scheme

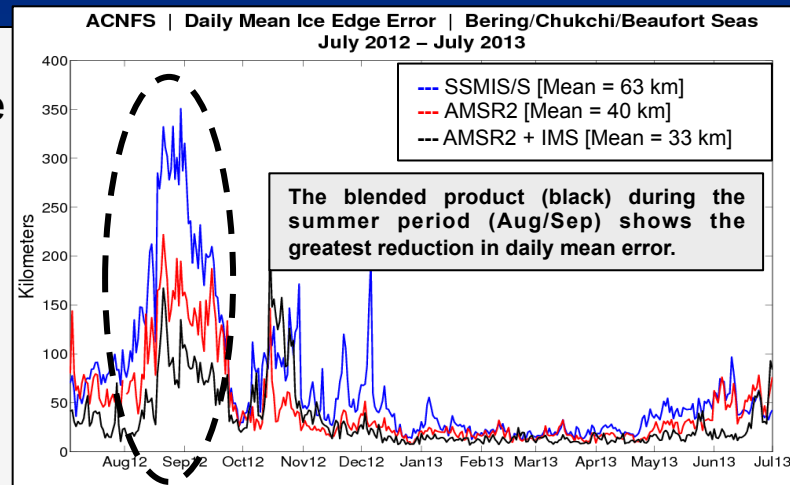
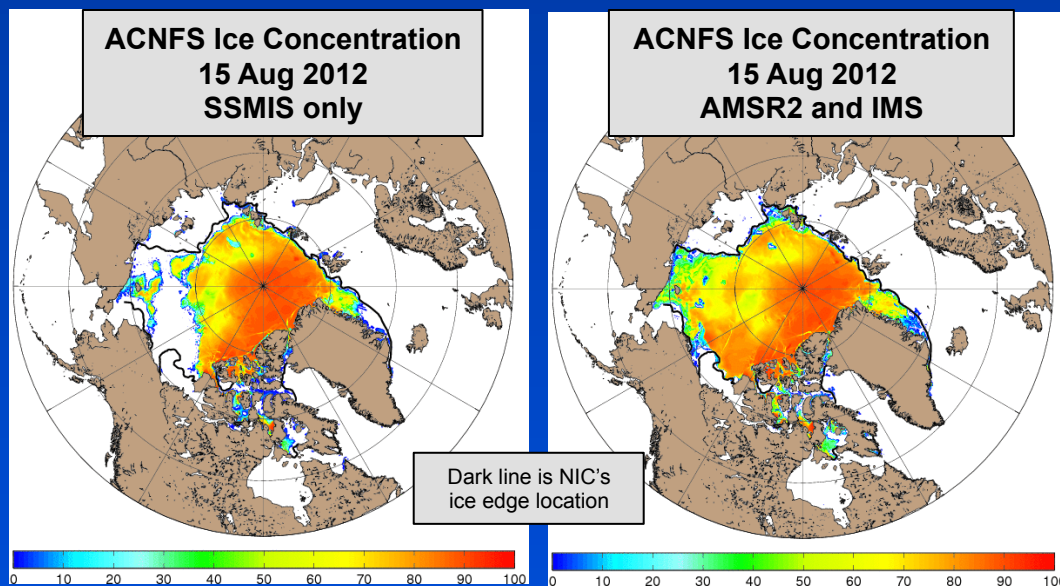






# Implementing high resolution satellite data into Navy's forecast systems

- Since the late 1990's, DMSP SSMI and then SSMIS ice concentration (25km) has been assimilated in the Navy's ice forecast systems.
- Passive microwave sensors have a known problem identifying melt ponds as open water which leads to underestimating sea ice especially during the summer.
- Developed technique with National Snow and Ice Data Center (NSIDC) to assimilate: AMSR2 (10km) and NIC's Interactive Multisensor Snow and Ice Mapping System (IMS) ice mask (4km).



- Sensitivity studies assimilating SSMIS, AMSR2 and IMS data sources were completed.
- Adding in new data sources (AMSR2 and IMS), overall ice edge errors in the Arctic were reduced by **36%** and **56%** (year and summer, respectively).
- Submitted paper to "The Cryosphere" – Posey et al., 2015

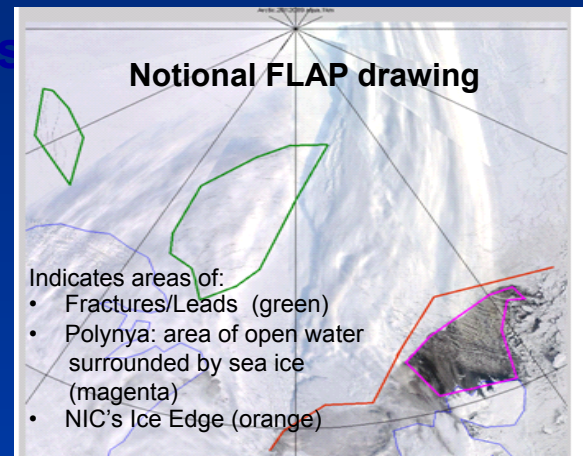
**New data sources implemented into ACNFS and GOFS 3.1 on 2 Feb 2015.**



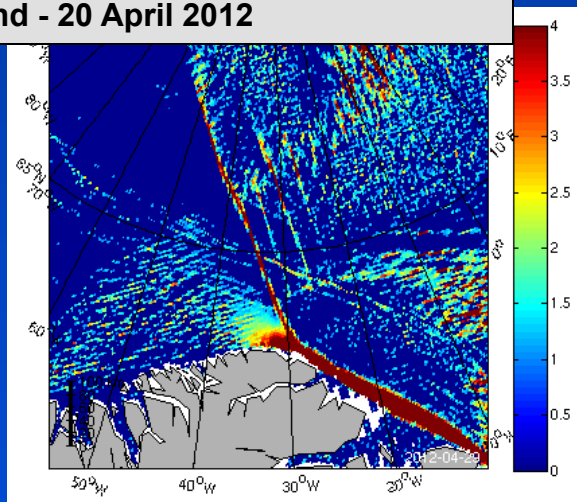
# Fractures, Leads and Polynyas (FLAP)

Naval Ice Center's – Fractures, Leads and Polynyas (FLAP)

- NIC provides on-demand FLAP information to SUBFOR prior to/during Arctic transit to indicate areas of ice openings
- Needed when surfacing for communications and emergencies
- Constructed by analysts using available satellite data
- Evaluation of ACNFS/GOFS 3.1 FLAP-product matched 80-90% of NIC FLAP messages from 2014
- Completed operational testing by NIC – June 2015



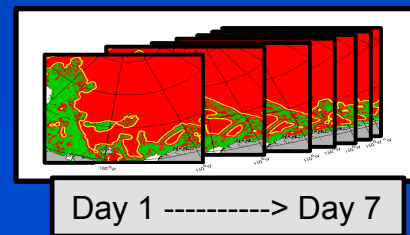
**MODIS image (left) vs ACNFS opening rate (right) off the northern coast of Greenland - 20 April 2012**



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OVLY/  
 LINE/4/A/2/820000N/090000W/814928N/090000E/790000N/028000E/790000N/028500N  
 LINE/5/G/4/798103N/0007475W/79977N/0003875W/804876N/004873E/804634N/0117584E/826847N/0225487E/01377584E  
 ARMS/ICE\_EDGE\_BOUNDARY  
 LINE/7/R/2/034867N/0628457W/846448N/0748564W/846957N/0742857W/847082N/06745847N/8468822N/585784W/839484  
 7N/0474756W/034867N/0628457W  
 ARMS/NUM\_FRACTURES1 E-W DIR  
 LINE/9/R/2/828476N/0164738W/0198374W/838489N/0249876N/8397466N/0268847N/865758N/0255587W/8727  
 785N/0145858W/8737783N/01487478E/8448776N/0076678W/8348479N/0103887W  
 ARMS/NUM\_FRACTURES2 E-W DIR  
 LINE/8/R/1/803847N/0268685E/804785N/0178738E/807734N/0134812E/8087002N/01863392E/817487N/0300743E/8170  
 08N/0348288E/826883N/0349857E/822847N/0348667E/817864N/2902378E/801739N/0268002E/ 8038477N/0268685E  
 ARMS/POLYNIA  
 RMKS/ICE\_EDGE\_ANALYSIS FROM 3/28 - 3/29 MODIS, ANALYSIS FROM 3/29 RADARSAT AND MODIS

**Forecasting FLAPS  
products –  
Green indicates FLAP areas**



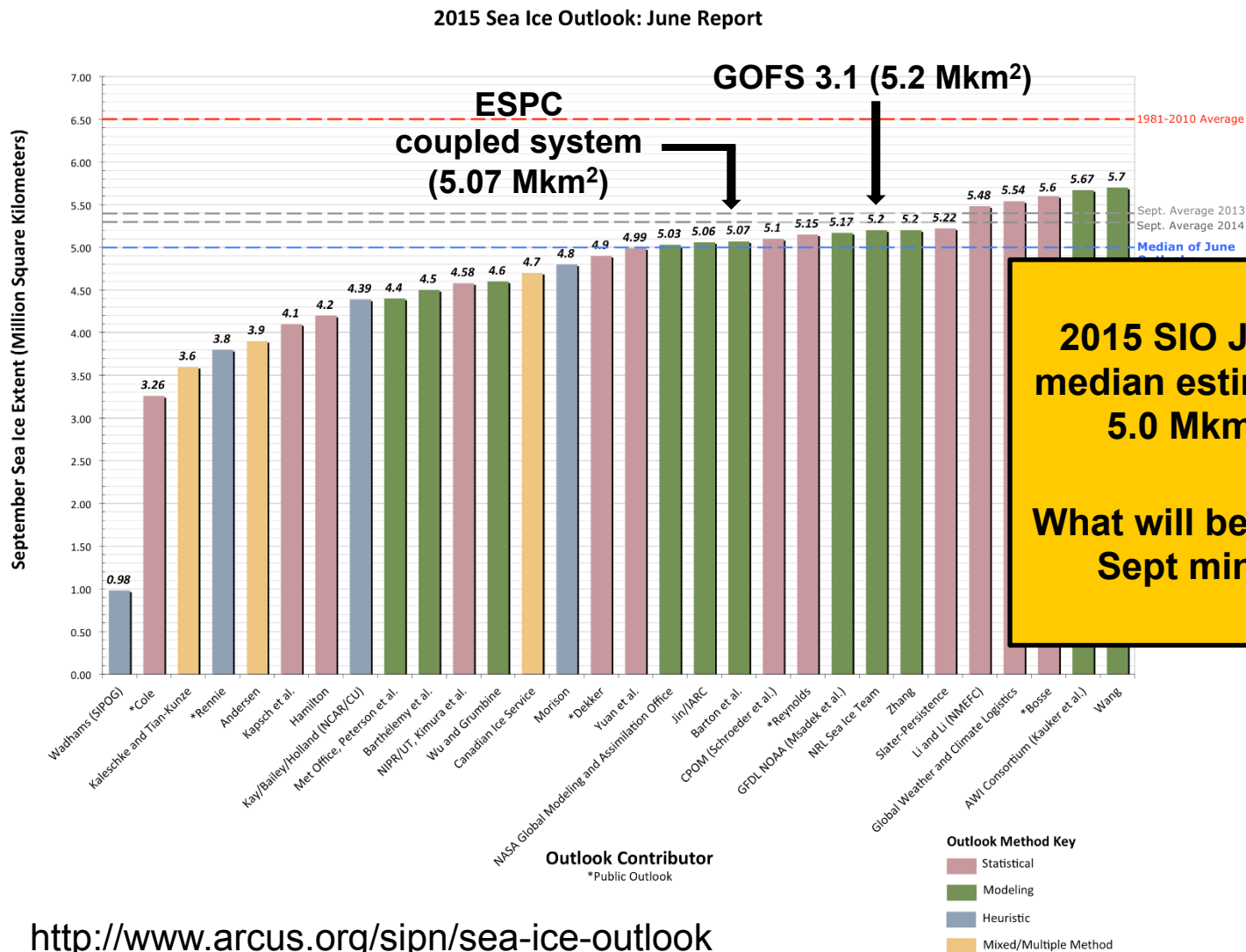




# Sea Ice Prediction Network (SIPN)

## Sea Ice Outlook (SIO) 2015

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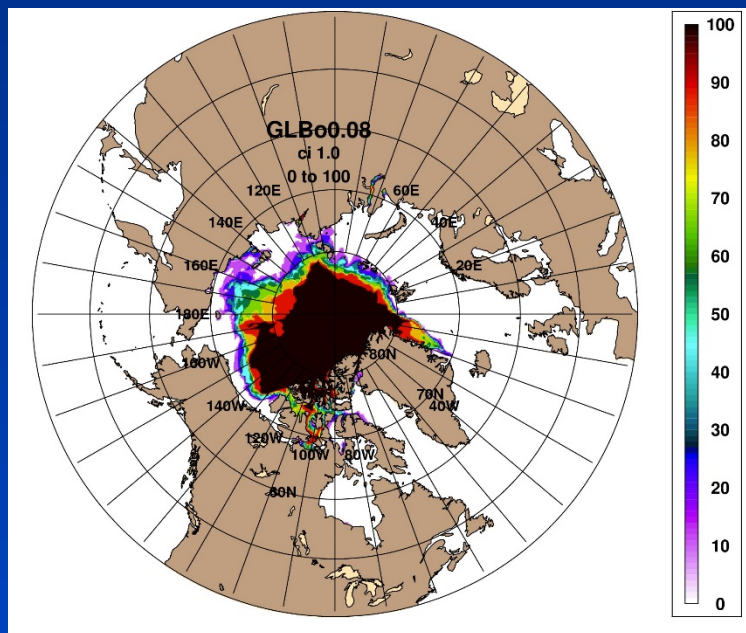


<http://www.arcus.org/sipn/sea-ice-outlook>



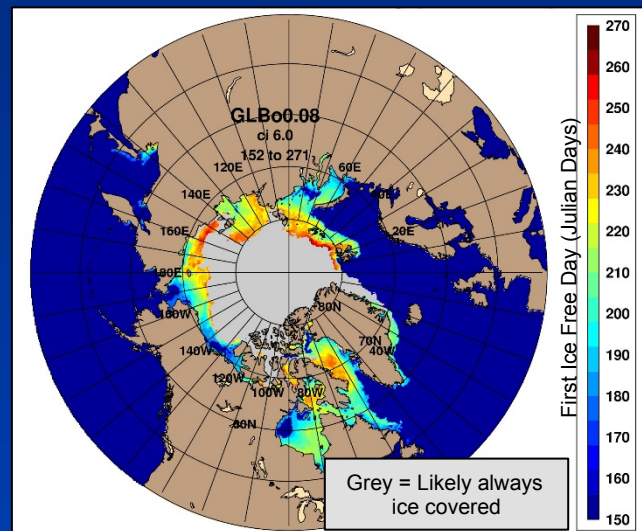
# New this year in the Sea Ice Outlook!

Estimate the September Sea Ice Coverage Probability:



Additional task for the sea ice modeling team: Initialize from PIOMAS ice thickness

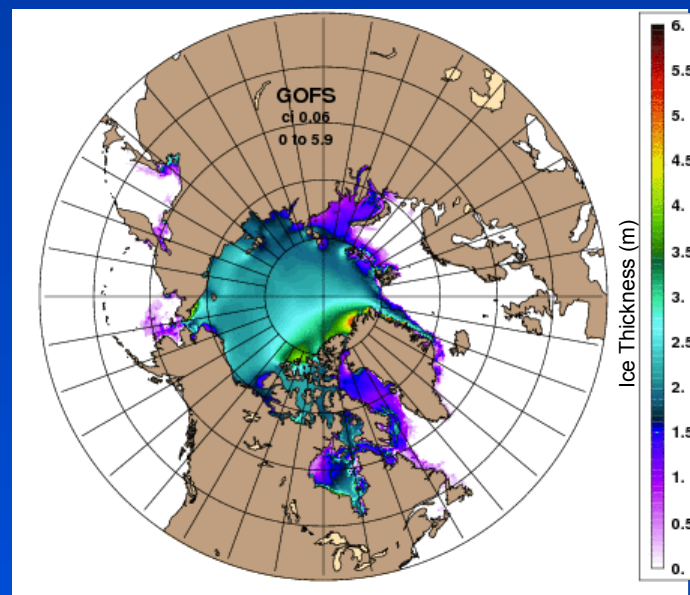
Estimate the First Ice Free Day:



17 Sep 2015

10 Aug 2015

29 Jun 2015

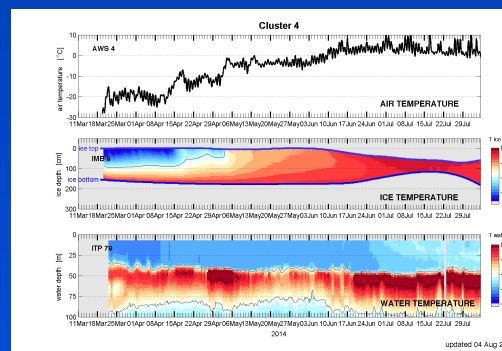
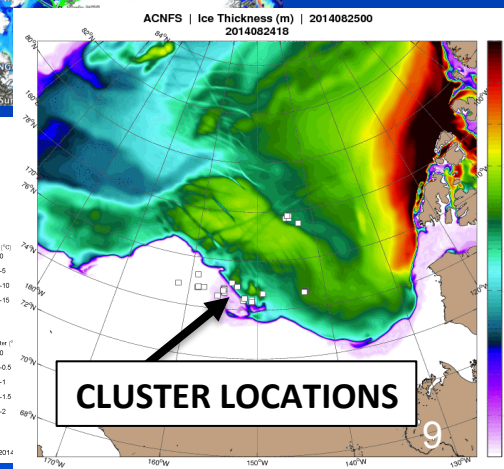
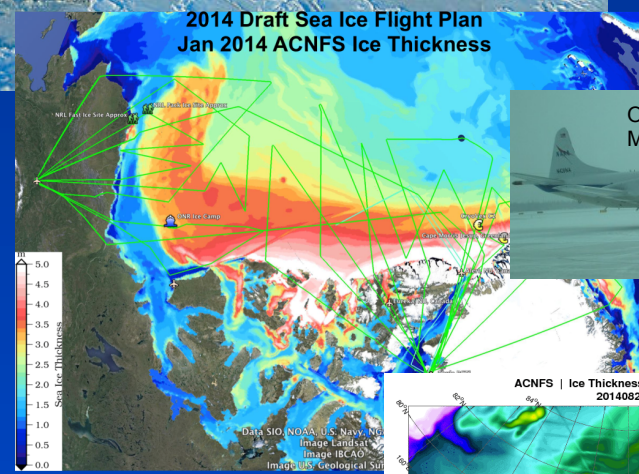
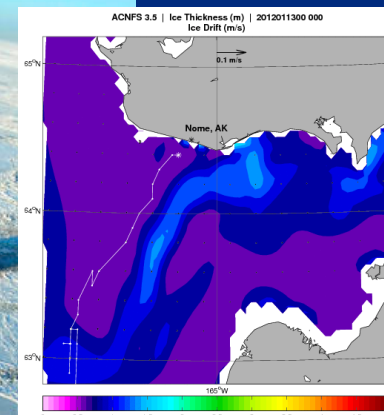






# ACNFS Used in Special Mission Support

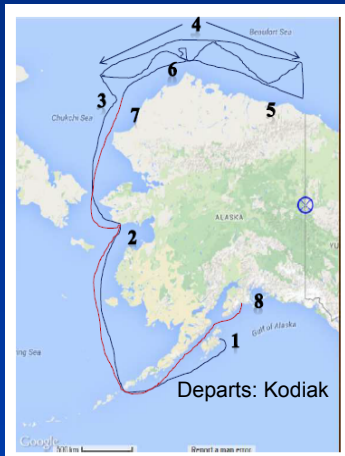
- Nov 2011-Jan 2012: ACNFS products provided guidance for convoy (CG Healy and Russian tanker) to deliver 103 M gallons of fuel to Nome, Alaska.
- Provided ACNFS products to assist in NASA Operation Ice Bridge pre-flight planning.
- Provided ice forecast products to ONR Marginal Ice Zone (MIZ) field work March – Sept 2014.





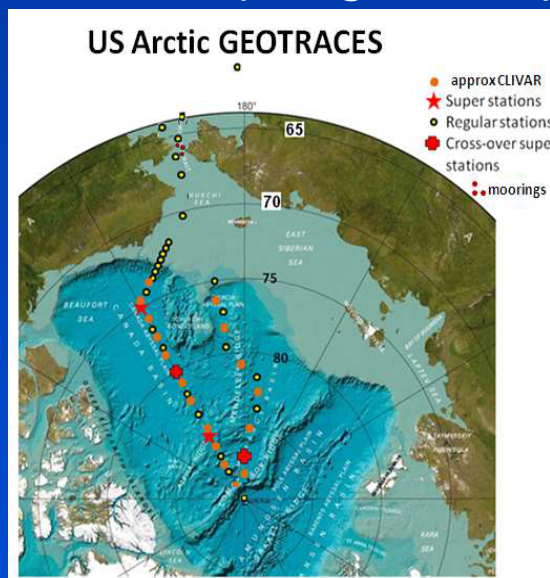
# NRL's real-time support – Summer 2015

## HLY-1501 (3-26 July)



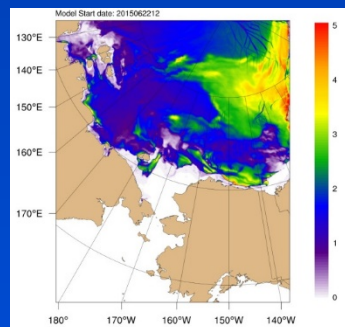
- A regional high resolution (2 km) loosely coupled air/ocean/ice (with data assimilation) has been set up to support Healy operations from July 3 – Oct 12, 2015.
- Products are made available to the NIC and US Coast Guard.
- In addition, the ONR Sea State DRI participants will have access to the products through early Nov.
- Navy's first real-time production capability using a regional sea ice system with high resolution atmospheric forcing for an extended period of time.

## HLY-1502 (9 Aug – 12 Oct)

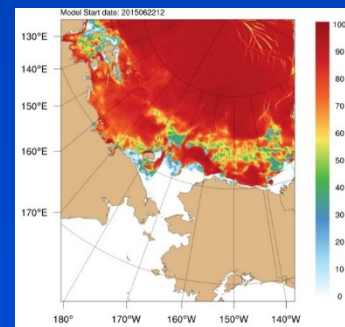


## Sample NRL regional ice products

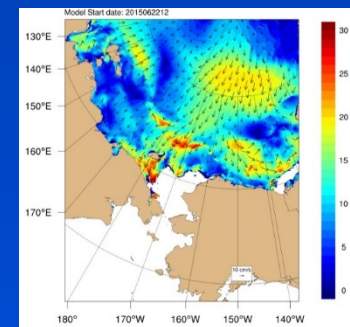
### Ice Thickness (m)



### Ice Concentration (%)



### Ice Drift (m/s)



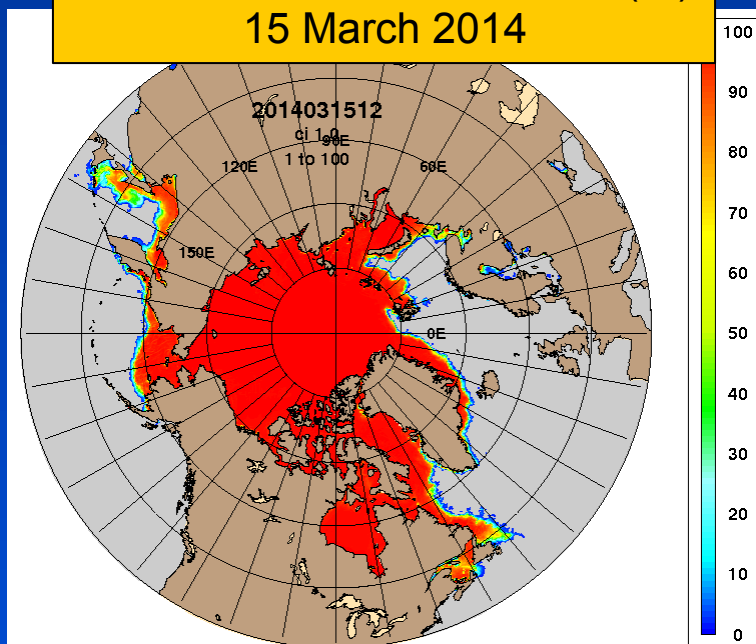




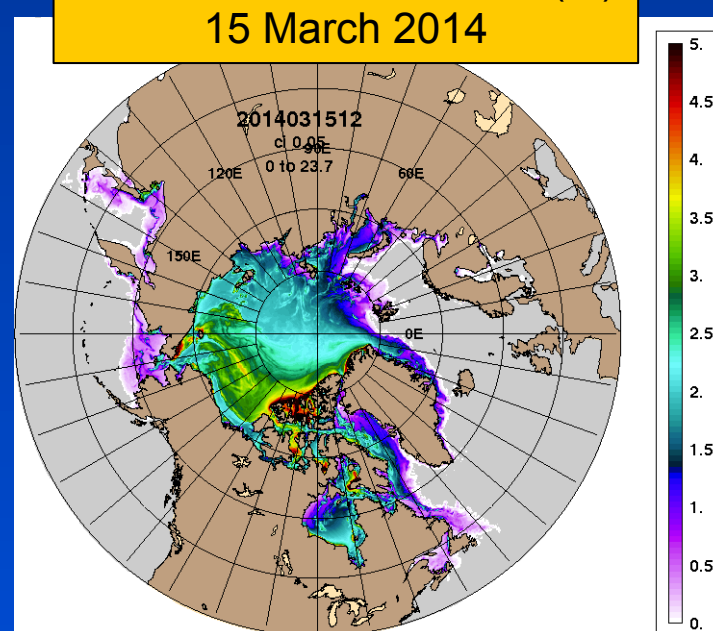
# Future operational products: GOFS 3.5

- 1/25° global two-way coupled HYCOM-CICE modeling system with data assimilation including tides
- Resolution 1.75 km at the North Pole (double res of GOFS 3.1)
- Hindcast simulations are currently underway from Jan 2014 forward
- Transition to NAVO scheduled for FY17

GOFS 3.5 Ice Concentration (%)  
15 March 2014



GOFS 3.5 Ice Thickness (m)  
15 March 2014

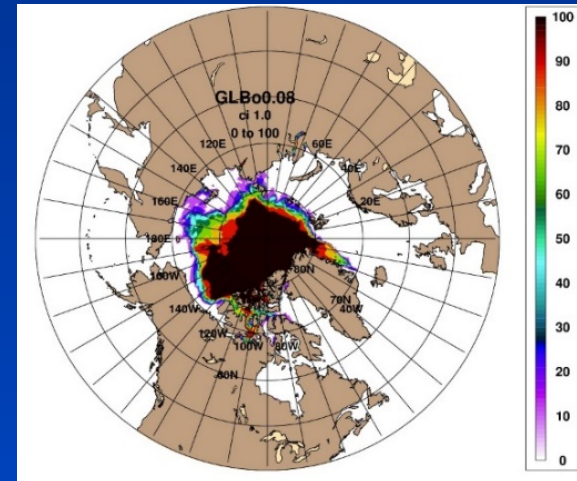




# Future operational products: Earth System Prediction Capability (ESPC)

- National, multi-agency collaborative effort to leverage resources to develop the next generation whole earth prediction system
- Includes components:  
atmosphere/ocean/ice/waves/land/aerosol
- Runs in fully coupled mode including an ensemble prediction capability
- Provide guidance in forecasting:
  - Arctic sea ice extent and seasonal ice free date
  - Extreme weather events
  - Extend lead-time for tropical cyclone prediction

GOFS 3.1 seasonal  
ice forecast



Navy's ESPC first generation system is scheduled to be running in real-time by 2018.



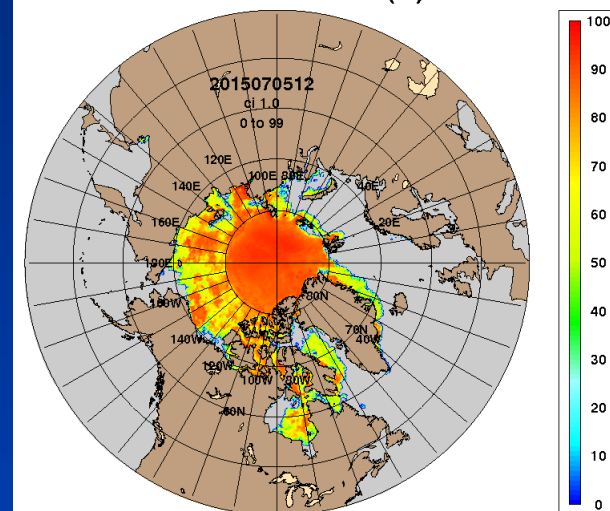


# Summary

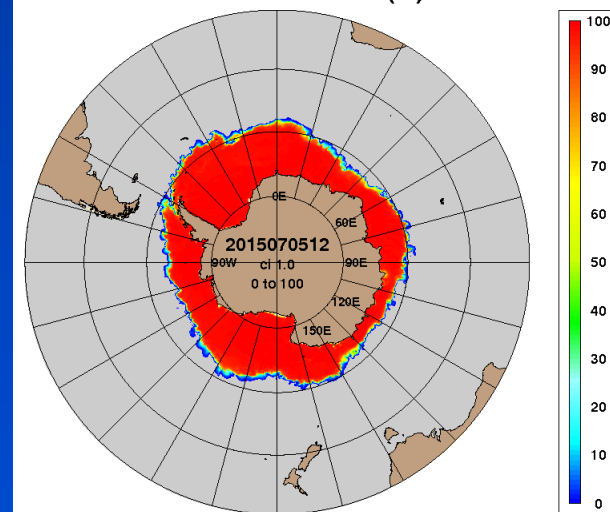
- **Operational ice forecast systems**
  - ACNFS (current operational system)
  - GOFS 3.1 (will soon replace ACNFS)
- **Improving forecast and new products**
- **Sea Ice Outlook – seasonal forecasts**
- **Products used in mission support**
  - HEALY summer cruises
  - ONR DRI fieldwork
  - NASA IceBridge
- **Ongoing Research**
  - Relocatable regional systems
  - GOFS 3.5
  - ESPC (fully coupled whole earth system)

## GOFS 3.1 Ice Concentration 20150706

GLBb0.08-92.4 Ice Concentration (%): 20150706



GLBb0.08-92.4 Ice Concentration (%): 20150706



Thank you!  
Questions?

